Building a Reliable Product

Army Reliability Improvement Initiatives

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The Army is rapidly pursuing new reliability improvement initiatives that support and implement recent Defense Science Board and Department of Defense Reliability Improvement Working Group recommendations. Those initiatives are crucial and are needed now. Army and DoD system reliability values are on a downward turn. Even moderate degradations in system reliability, on the order of 10 percent, equate to billions of dollars in additional costs over the life cycle of a major weapon system. Even more important, warfighters deserve the most reliable and rugged equipment possible. The new Army initiatives will provide an opportunity to improve system reliability, stop the downward spiral, and cost-effectively implement reliability best practices.

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The Army is taking a multi-pronged approach to improve reliability by establishing new reliability test thresholds, evaluating programs early using a new reliability scorecard, developing reliability growth tools, and increasing emphasis on early engineering analyses to positively affect designs during the development process. The Army's initiatives, detailed in this article, can be applied across DoD.

Army Reliability Policy

Under the new Army reliability policy approved in December 2007, an engineering and manufacturing development phase reliability test threshold will be established for all programs with a Joint Requirements Oversight Council joint potential designator of "joint interest." The threshold values will also be incorporated into solicitations for contracts. The policy—currently being added to the next revisions of Army Regulation 70-1, "Army Acquisition Policy," and Army Regulation 73-1, "Test and Evaluation Policy"—includes details for establishing the system reliability threshold. The threshold will be approved as part of the test and evaluation master plan and recorded in the acquisition program baseline at Milestone B. The system will be expected to meet or exceed the reliability threshold at the end of the first full-up, integrated, system-level developmental test event.

Achievement of the reliability threshold will be a major focus during design reviews. If a reliability threshold breach occurs, an in-process review led by the Army Test and Evaluation Command will convene to address:

- The program manager's planning and implementation of corrective actions and associated impacts
- The Army Test and Evaluation Command's assessment of the corrective action plan
- Ownership cost impacts
- System utility impact assessments from the Army Training and Doctrine Command.

The new policy also highlights some of the best commercial and defense reliability practices that programs should use to help ensure that the system reliability requirements will be met. The policy will provide senior Army leadership an earlier warning for those programs that are falling short of critical reliability targets.

Reliability Program Standard

DoD worked closely with both industry and the Government Electronics and Information Technology Association on the development of a new standard: GEIA-STD-0009, "Reliability Program Standard for Systems Design, Development, and Manufacturing." DoD was motivated to initiate and support the undertaking because many systems have not been achieving the required level of reliability during developmental testing and have been subsequently found unsuitable during initial operational test and evaluation. In May 2008, the Defense Science Board developmental test and evaluation task force examined those issues and concluded that a new reliability program standard—which includes reliability growth as an integral part of design and development, and can be readily cited in DoD contracts—was urgently needed.

GEIA-STD-0009 consists of the essential reliability processes that must be performed in order to design, build, and field reliable systems. GEIA-STD-0009 is, at its core, a reliability engineering and growth process that is fully integrated with systems engineering. In order to facilitate its use in DoD acquisition contracts, enabling sample language was developed; it which can be viewed at the Defense Acquisition University's Acquisition Community Connection Web site, <https://acc.dau.mil/communitybrowser.aspx?id=219127&lang=en-us>.

The sample reliability language consists of four parts:

- Section C, Statement of Work Reliability Language and Tailoring Instructions. If Section C of a request for proposal contains a statement of work, it is recommended that this sample reliability language be incorporated. Embedded tailoring guidance is included in the sample language. If Section C does not contain a statement of work, then it is recommended that a statement be included in the statement of objectives requiring that the sample reliability language be included in the contractor statement of work.
- Section L, Proposal Instructions Reliability Language. Section L of a government contract lays out the specific preparation requirements for submissions.
- Section M, Evaluation Factors for Award Reliability Language. Section M relays the factors used to determine how the government plans to compare each bid and which criteria are most important to them.
- Checklist for Evaluating Reliability Program Plans. The checklist can be used to evaluate draft reliability program plans developed based on the reliability statement of work language.

It is also recommended that GEIA-STD-0009 be explicitly cited in the system specification, which is typically included in Section C of the request for proposal.

Reliability Scorecard

The reliability scorecard examines a supplier's use of reliability best practices and the supplier's planned and completed reliability tasks. The scorecard can also be used to evaluate a given program's reliability progress. The scorecard was developed based, in part, on reliability assessment approaches developed by the Institute of Electrical and Electronics Engineers, Raytheon, Alion, the University of Maryland, and others. The Army Materiel Systems Analysis Activity (AMSAA) and the Army Evaluation Center expanded and refined the individual assessment areas based on several years of evaluation and reliability program experience.

The latest version of the scorecard allows quantitative assessment across eight critical areas:

FROM OUR READERS

Great Lessons Learned

I would like to praise Wayne Turk's article "Be Willing to Make Changes," which appeared in the May-June 2009 issue of *Defense AT&L* magazine. It is very timely considering all that is going on in the DoD environment. Not only was the article concise and well-written, but the author hit all the critical points of change management, especially participative involvement, explaining what's in it for those impacted by the change, creating a sense of urgency, and using middle managers to explain the new process and its benefits. Great idea for a checklist!

To quote Woodrow Wilson, "If you want to make enemies, try to change something." That is very true! Hopefully, *Defense AT&L* readers will take advantage of Turk's article to select the right changes to make and implement them well. Too often, managers naively expect that those impacted by the change to embrace it and understand it from an "all-hands" e-mail. Successful change, as Turk points out in his article, takes a lot of planning and work.

I also liked the article "Leaders as Circus Performers," by Fred Jones, Doug McCallum, and Chris Sargent, also appearing in the May-June 2009 issue. The analogy of plate-spinners (high-level leaders) versus jugglers (lower-level leaders) is a good one. I also liked the analysis of the feedback the authors got from previous surveys. Too often, people are asked to respond to a survey, never hearing the results or, more important, never learning what actions were taken as a result of the survey.

The authors also hit the key reasons surveys are not used more often by leaders: ignorance, fear, and skepticism. Hopefully, the article will help leaders overcome those feelings.

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The Army is taking a multi-pronged approach to improve reliability, establishing new reliability test thresholds, evaluating programs early using a new reliability scorecard, developing reliability growth tools, and increasing emphasis on early engineering analyses.

- Reliability requirements and planning
- Training and development
- Reliability analysis
- Reliability testing
- Supply chain management
- Failure tracking and reporting
- Verification and validation
- Reliability improvements.

Each element is rated red, yellow, or green based on a number of questions. Quantitative risk scores are provided for each assessment area as well as for the overall system. This scorecard is important for tracking the achievement of reliability requirements and rating the adequacy of the overall reliability program. The scorecard can be accessed from the Defense Acquisition University's Acquisition Community Connection Web site at <https://acc.dau.mil/communitybrowser.aspx?id=210483&lang=en-us>.

New Reliability Growth Tools and Test Bed

AMSAA has produced several new reliability growth models. One such model is the planning model based on projection methodology (PM2). Many times, analysts will produce system-level reliability growth planning curves that, at first glance, appear reasonable and achieve the desired goals with the given set of input parameters. However, those curves often do not allow for the impacts associated with schedule, testing, refurbishment, and block updates. By not accounting for those very real constraints, the system-level reliability growth planning curves can portray an overly optimistic and unrealistic program for achieving the system-level

reliability. Those constraints could be addressed using older reliability growth methodology, but not in a systematic way.

Planning models can be made more realistic by incorporating some of the methodology used for reliability growth projection, as demonstrated by the PM2 model. The projection methodologies account for key engineering and schedule decisions such as fix effectiveness factor levels, management strategy, delays for incorporating fixes, and refurbishment period scheduling.

The PM2 model starts by determining the reliability testing operating hours, which are officially scored, as a function of calendar time for each individual system included in reliability growth testing. Then for each platform calendar schedule, the blocks of time where corrective actions are implemented (i.e., refurbishment periods) are inserted. Next, an estimate for the average time between the occurrence of a new problem failure mode and when a corrective action can be inserted is applied. The user then develops an idealized growth curve using projection methodology. The user specifies the initial mean time between failure, the goal mean time between failure, the planned value of the average fix effectiveness factor, the management strategy, and the allocated test time. Those five values define the idealized growth curve. The idealized curve gives the expected mean time between failure as a function of test time; and offers a number of highly useful metrics that provide the program manager and other members of the acquisition community with a valuable means to assess the reliability program, testing program, number of assets available, and the availability of engineering resources to maximize the chances of producing a highly reliable and cost-effective system.

The AMSAA PM2 reliability growth planning curve sets a much better expectation for what reliability values should be achieved as part of the system development process. Often with idealized curves, the reliability values are overly optimistic. In many programs, a large portion of the testing hours actually occurs towards the end of the program or immediately before a major milestone. The idealized curve often shows that the desired reliability is achieved by the milestone. However, when actual schedule and corrective constraints are placed on the planned reliability growth curve, engineers and management can see where the real bottlenecks are and better allocate their test time, engineering activities, refurbishment periods, and test assets in order to meet the reliability goal with minimal risk. The model has recently been released in a Microsoft® Excel spreadsheet format and is available to U.S. government employees and defense contractors, who can request access to the model by e-mailing apgr-amsa-reltools@conus.army.mil.

Another supporting advance is the new reliability simulation test bed, which examines the potential reliability growth of complex systems. The goal of the test bed is to examine the impacts of various reliability growth strategies on the overall system reliability and the accuracy of associated statistical model reliability assessments. The simulations are conducted by making random draws of initial mode failure rates from several parent populations. The simulation is unique in comparison to others of this type in that it allows for flexibility in implementing corrective actions. The corrective actions may be implemented during the test phase of the system or delayed until the end of the overall test period. When implemented during the test phase, the corrective actions are implemented either through built-in corrective action periods within the overall test phase or during the test periods themselves.

In the near term, existing Army reliability growth models are to be converted to an Excel-based format to allow more DoD personnel and contractors to easily implement the latest in reliability growth modeling without cost.

Physics of Failure

The Army continues to successfully apply physics of failure modeling to a wide variety of vehicles and electronics systems. PoF is a science-based approach to reliability that uses modeling and simulation to design reliability into a product, perform reliability assessments, and focus reliability tests and screens where they will be the most effective and productive. The PoF approach involves modeling the root causes of failure—often called failure mechanisms—such as fatigue, fracture, wear, and corrosion. The basis of PoF is that it is not only important to understand how things work but also, equally important, to understand how things fail. Computer-aided design tools have been developed to address various loads, stresses, failure mechanisms, and failure sites.

PoF modeling has been critical for systems currently supporting Operation Iraqi Freedom and Operation Enduring Freedom. For example, the PoF modeling provided a quick and efficient way to mitigate the weight impacts of new armor packages and maintain system reliability for warfighters.

Increasing Weapons System Reliability

The initiatives discussed in this article are just some of the ways that the Army is working to further increase weapons system reliability. These initiatives are cost-effective and will provide significant returns on investment—and even greater benefits for our warfighters.

U.S. government personnel and their DoD contractors interested in obtaining, at no cost, reliability growth models, the reliability scorecard, or associated training can send an e-mail request to apgr-amsa-reltools@conus.army.mil.

The authors welcome comments and questions and can be contacted at apgr-amsa-reltools@conus.army.mil.